JOURNAL OF APPLIED SCIENCE AND SOCIAL SCIENCE
eISSN 2229-3113 pISSN 2229-3205

Volume 15 Issue 03, March 2025
Impact factor: 2019: 4.679 2020: 5.015 2021: 5.436, 2022: 5.242, 2023: 6.995, 2024 7.75

# SCIENTIFIC AND METHODOLOGICAL BASIS FOR DEVELOPING SPATIAL REPRESENTATIONS IN STUDENTS WHEN TEACHING THE TOPIC "TYPES" IN THE COURSE OF ENGINEERING GRAPHICS

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**Abstract:** This article examines the scientific and methodological foundations for developing students' spatial representations when teaching the topic "Types" in the engineering graphics course. The study analyzes the role of innovative pedagogical approaches in the formation of spatial representations and their impact on the educational process. The paper examines the use of modern technologies, including 3D modeling, virtual reality and gamification (from the English gamification) as methods that contribute to the development of skills in creating and perceiving images. It also examines the use of collaborative teaching methods that promote cooperation between students and allow organizing the educational process in an interactive form. The results of the study are aimed at improving the quality of education and improving pedagogical methods.

**Keywords:** Engineering graphics teaching, spatial representations, types, innovative approaches, 3D modeling, virtual reality, gamification, collaborative learning, interactive learning, pedagogical methods.

**Introduction.** One of the most important tasks of the engineering graphics course is to develop spatial imagination and spatial thinking abilities in students. The topic of "Views" is especially important in this process. This article examines the scientific and methodological foundations for the formation of spatial representations in students when teaching the topic of "Views". Engineering graphics is an integral part of modern engineering education. This course teaches students not only how to understand and create drawings, but also significantly contributes to the development of their spatial imagination. In the context of the rapid development of technologies and production processes, the emergence of new materials and equipment in the engineering field, specialists are faced with higher requirements. For successful professional activity in the engineering field, not only theoretical knowledge is important, but also practical skills, such as the ability to understand, analyze and create drawings and spatial models [1].

In addition, engineering graphics requires not only working with traditional paper drawings, but also the use of modern computer programs (AutoCAD, SolidWorks, CATIA and others). These programs significantly increase the requirements for spatial thinking, since in the process of working with them it is necessary to analyze three-dimensional models, optimize drawings and technical projects [6]. However, in the process of training, an urgent problem arises of insufficient development of methods aimed at developing spatial imagination, as well as the difficulties that students face when mastering the educational material. Many studies show that the effective organization of the educational process in engineering graphics, especially in the formation of students' spatial representation and their ability to solve engineering problems, is of great importance [12]. Today, the development of pedagogical technologies, including 3D

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modeling, virtual and augmented reality, opens up new opportunities for learning. The use of these approaches contributes to more active participation of students in the process of acquiring knowledge, the development of their spatial representations and an increase in the ability to independently solve real problems. Therefore, scientific and methodological research aimed at developing spatial representation in the process of teaching engineering graphics is relevant.

**Purpose and objectives of the study**

Purpose of the study. To determine the scientific and methodological foundations for the development of students' spatial representation in the process of teaching engineering graphics, to develop effective pedagogical technologies and to ensure their integration into the educational process.

Objectives of the study. To achieve the purpose of the study, it is proposed to complete the following tasks:

1. Study of theoretical foundations: Analysis of the psychological, pedagogical and didactic foundations of engineering graphics and the development of spatial representation. Also, study of the importance of using modern technologies in the educational process.

2. Analysis of the problem: Identification of the main problems arising in the development of students' spatial representation in the process of teaching engineering graphics, and analysis of existing approaches to solving them.

3. Development of methodological approaches: Development of effective teaching methods aimed at developing students' spatial representation in teaching engineering graphics. Determination of the possibilities of using new technologies.

4. Practical application: Organization of the application of the developed methods in the educational process and evaluation of their effectiveness.

5. Experimentation and analysis of results: Conducting experimental tests of methods in the educational process and drawing conclusions based on the results obtained.

6. Development of recommendations: Development of methodological recommendations aimed at developing spatial representation in teaching engineering graphics, and their presentation to teachers and educational institutions.

These goals and objectives increase the scientific and practical value of the study, and its results contribute to improving the quality of the educational process in engineering graphics.

The engineering graphics course, especially the topic "Views", plays an important role in the formation of students' spatial representation. Views mainly include the image of objects in three dimensions and the presentation of these images in accordance with the real spatial structure. However, many students have difficulties with the correct and accurate understanding of views in engineering graphics, as well as with expressing their spatial position. This problem has

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several causes and consequences.

Reasons: Insufficient attention to the development of spatial representations: Many curricula do not pay enough attention to the development of spatial representations. Students often study only theoretical aspects and mathematical formulas, as a result of which their spatial representations become more complex.

Disadvantages of teaching methods: The methods used to explain views in engineering graphics lessons are often traditional and static, which does not provide sufficient opportunities for the development of students' visual perception. The possibilities of using dynamic graphic images or advanced technologies using computers may be limited.

Complexity of images: The section "Views" in the engineering graphics course sometimes seems very complex and abstract to students. This creates problems in the development of their spatial perception.

Cognitive and psychological factors: Students often face individual difficulties in forming spatial representations. This may be due to cognitive abilities, psychological barriers in creating clear representations, or insufficient adaptation of the teaching material [5].

Consequences:

Errors and inaccuracies: Due to the fact that students are unable to correctly or accurately depict views, an error may occur in the design or development process. This, in turn, can lead to serious problems in production processes.

Delay in the development of spatial representations: This problem occurs when students are unable to form their spatial representations correctly, which causes difficulties in studying other subjects such as general technical, specialties, engineering and other related fields.

Decreased creativity: Difficulties in the development of images and spatial representations negatively affect the ability of students to think creatively and develop innovative approaches.

Theoretical basis of the study: Spatial representation is the ability of a person to reflect in his mind the shape, location and movement of objects in three-dimensional space, as well as to imagine their characteristics. The course of engineering graphics plays an important role in the practical development of spatial representations, as it forms knowledge and skills in the image, design and production processes of technical objects and structures in three-dimensional format[3].

The problem of the development of spatial representations is studied in various scientific fields, including psychology, pedagogy, cognitive sciences and teaching methods. The following theoretical approaches are important for the formation and development of spatial representations:

Cognitive Psychology: Cognitive psychology links spatial representations with images, memory, and perceptual processes in the human mind. Medical and psychological research shows that

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human spatial representations are closely linked to memory and learning processes, which in turn directly affect students' ability to move, reflect images, and correctly create graphic expressions. Clear representation of images is important for students' intellectual development and their success in technical fields.

Pedagogical approaches: In pedagogical science, the study of spatial representations and methods of their development is of particular importance. Pedagogical theories emphasize that activity and interactivity play a key role in the formation of spatial representations in the educational process. Such methods include the creation of views using advanced technologies, the use of virtual reality and interactive programs, as well as the exchange of experience through visual means [13].

Visualization and graphic methods: Graphic methods and visual means play an important role in teaching the topic "Views". The development of spatial representations using graphic images, the ability to display and change three-dimensional objects in two dimensions helps students understand complex technical processes. To deepen knowledge of images, the use of visual materials, diagrams, computer graphics and modeling methods is effective.

Didactic approaches to the development of spatial representations: In didactics, there are several basic principles aimed at developing spatial representations:

1. Active and problem-based teaching methods: Students should independently work on the development of images and spatial representations. Through active and problem-based learning methods, students learn to express their thoughts, solve various spatial problems, and apply their knowledge to solve real-world problems.

2. Modeling and interactive technologies: Interactive computer programs, simulations, and virtual models can be used to explain images and develop spatial representations, making the learning process more effective. Automatic modeling of images using a computer teaches students not only theoretical but also practical skills.

3. Visual aids: For studying the topic "Types", high visual aids in illustrating the material help students understand it better. 3D modeling, scanned images, animations, and tools that show changes in real time can be used as visual aids.

The methodology for teaching engineering graphics helps students master technical knowledge and develop images and spatial representations. This methodology is based on the following main principles:

- Step-by-step teaching of images, strengthening each stage, and supporting with practical exercises are important for developing spatial representations. First, students master two-dimensional images, and then move on to three-dimensional ones, gradually deepening their knowledge.

One of the effective methods for developing spatial representations is practical classes and training. Using graphic programs, creating 3D models and virtual images allows students to test

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their knowledge in practice.

Innovative approaches to developing spatial representations are aimed at stimulating students' creative thinking, improving their practical skills and improving the effectiveness of learning using modern technologies. In the process of teaching the topic "Views" in engineering graphics, innovative approaches help to form students' spatial representations, creating images in their minds and providing a more accurate and effective expression of these representations. Below are considered the main innovative approaches that can be applied in this area.

The use of computer technology in teaching engineering graphics helps students understand views more effectively and accurately. Today, computer programs, CAD (Computer-Aided Design) systems, 3D modeling and simulation tools serve as important tools for developing spatial understanding. The following innovative approaches can be used in this area:

- With the help of programs such as AutoCAD, SolidWorks, SketchUp, students are taught to create three-dimensional (3D) models and apply views to them. These systems are especially useful for applying spatial understanding in practice in engineering and architecture. 3D modeling allows students to quickly create different views of objects and analyze them.

- With the help of virtual reality (VR) and augmented reality (AR) technologies, students are offered new approaches to creating and understanding spatial understanding. For example, with the help of VR technologies, students can explore 3D objects interactively, modify them and analyze them in real time. AR technologies allow the creation of virtual images that are connected to the real world in an interactive format[11].

One of the innovative approaches is the use of interactive learning materials and online platforms. This method gives students the opportunity to consolidate their knowledge, personalize the learning process, and develop skills through interactive activities.

On online platforms (e.g. Moodle, Google Classroom, Edmodo), the creation of interactive lessons and tests encourages students to actively participate in the acquisition of the material. Interactive imagery lessons teach students to create various graphic forms, analyze them, and modify them. Students can also reinforce their knowledge with the help of online tests.

Another innovative approach is the use of video materials, animations, and illustrative materials when studying the topic of “Views”. With the help of animations, spatial representations can be visually explained and concepts that are difficult for students can be simplified for them.

Gamification is the use of game elements in the learning process. This method helps to make the learning process interesting and motivating for students. Gamification can be used to offer students various games and tasks to create images. The main goal of this process is to encourage students to solve problems through competition, while simultaneously teaching them[9].

Using gamification elements in creating images and spatial representations teaches students to solve various spatial problems in an interactive environment. For example, virtual games can teach students to correctly depict objects in three dimensions, show them from different angles

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and change them.

Among the innovative approaches, collaborative learning and team projects play an important role. This method helps to develop cooperation among students, solve problems in a team and stimulate creative thinking[10].

Students can work on projects by creating images and analyzing them in teams. This process is especially effective in the field of engineering graphics and architecture, as students can learn from each other, collect different ideas and create improved solutions.

Using tools on online platforms that allow students to work collaboratively (e.g. Google Docs, Trello) facilitates the exchange of opinions, the development of schedules and joint problem solving.

Collaborative learning is a teaching method aimed at developing cooperation among students. In this method, students work in a group, help each other, and solve problems together. Collaborative learning deepens the learning process through the exchange of opinions, sharing knowledge, and making decisions together[14].

In the study of engineering graphics and the topic "Views", providing each student with an individual approach, that is, using personalized learning, is important. This teaching method takes into account the differences between students, their individual requirements, abilities, and needs.

One of the innovative approaches is the creation of personalized curricula. These programs are adapted to the individual characteristics of students based on their self-assessment and help to customize the learning process to their specific needs[10].

The theoretical significance of the study lies in the deep analysis of the scientific and theoretical foundations of the development of students' spatial representations when teaching the topic "Views". This study contributes to the creation and promotion of new knowledge, theoretical approaches, and concepts. It also develops new approaches and methods for the development of spatial representations. For example, it can create opportunities for improving the methods of teaching types and introducing advanced theories of spatial representation formation in cognitive psychology and pedagogy. This can become the basis for scientific and correct organization of the educational process.

The study promotes new scientific ideas and didactic methods in the field of engineering graphics. By analyzing the methodological foundations of developing spatial representations in the topic "Types", it contributes to the scientific improvement of the teaching process of this discipline.

The theoretical significance of the study is that this work can become the basis for other scientific research. It adds new knowledge to the literature in such areas as engineering graphics, pedagogy, cognitive psychology, and creates opportunities for developing new scientific

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directions.

The study considers innovative approaches to teaching the topic "Types", for example, 3D modeling technologies, virtual reality and gamification, which opens up opportunities for creating scientifically new methodologies. These approaches can benefit not only the educational process, but also the entire education system as a whole. The practical significance of the study lies in the development of results and recommendations for the application of the topic under study in the educational process, teaching methods and practice. The practical significance of the study can be revealed through the following points:

Development of students' spatial representations: The study develops innovative methods aimed at the effective development of students' spatial representations. These methods play an important role in the formation of knowledge of specialists in the field of engineering graphics and technical professions. Students will be able to apply their knowledge in practice, for example, more accurately create views, analyze them and make changes.

Improvement of teaching methods: The practical significance of the study lies in the fact that it helps teachers introduce new pedagogical methods, interactive and innovative approaches to teaching engineering graphics. For example, the use of 3D modeling, virtual and augmented reality, the introduction of gamification elements into the educational process will increase the effectiveness of learning. These methods help strengthen students' skills and prepare them for technical professions. Training of specialists for technical fields: The study helps to prepare highly qualified specialists for technical fields using new methods applied in studying the topic "Types" and developing spatial representations. Students develop their skills in creating spatial representations, which helps them to be successful in practice [15].

Updating pedagogical tools: The practical significance of the study is aimed at updating pedagogical tools. The introduction of innovative technologies and interactive methods in the educational process creates a more interesting and effective learning environment for students. The practical application of these pedagogical approaches improves the quality of teaching.

Justification of the research work: The practical significance of the study lies in the development of scientific developments, methods and technologies that can be used in the educational process. This contributes to increasing the effectiveness of teaching methods and improving the level of assimilation of the material by students. New approaches and materials for teachers are also provided.

The theoretical and practical significance of the study lies in the fact that it is important for the development of new approaches in the scientific and pedagogical spheres, the creation of new methods for the development of spatial representations of students.

The main findings of the study include the following (see Table 1):

Innovative methods and technologies: Innovative approaches such as 3D modeling, virtual and augmented reality (VR/AR), gamification can be effectively used to develop spatial representations. These technologies allow students to create views faster, more accurately and

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efficiently. With the help of computer programs and interactive learning materials, students can strengthen their knowledge and add motivation to the learning process.

Collaborative learning methods: As part of the study, collaborative learning methods were tested to ensure that students work in a team. This approach helps students to work together, learn from each other and solve complex problems in a group [14].

Interactivity of the learning process: The study emphasizes the importance of increasing the interactivity of the learning process and developing students' practical skills. This method helps to activate students and ensure a high level of their involvement in the learning process. Students are provided with opportunities to strengthen and improve their knowledge through online platforms, interactive lessons and games. Improving Teaching Methods: The study found that using innovative teaching approaches in combination with traditional methods in teaching the topic of "Views" contributes to more effective development of students' spatial understanding. Providing students with the opportunity to work with 3D graphics, create models and study them interactively expands their understanding and contributes to more effective understanding.

Personal Development of Students: Developing customized curricula for students' personal development, using individual approaches contributes to more effective development of their abilities. Individualized curricula take into account the differences between students and help meet their unique needs.

**Table 1**

| **Research Direction** | **Results** | **Real life application** |
|---|---|---|
| The Importance of Visual Materials in the Development of Spatial Representations | 3D models, interactive diagrams and virtual work help improve students' spatial understanding | With the help of 3D graphics and interactive tools, students better understand images in the learning process and make faster decisions in practical activities. |
| The Importance of Practical Classes and Laboratory Work | Students gained a better understanding of species and a more accurate representation of them by participating in practical exercises. | By creating technical drawings and modeling mechanical systems, students feel more confident and are able to develop complex designs with greater ease. |

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| | | |
|---|---|---|
| Innovative technologies and interactive learning | The use of computer graphics and CAD systems has proven to be effective in developing students' spatial understanding.. | By creating technical drawings and modeling mechanical systems, students feel more confident and are able to develop complex designs with greater ease. |
| Pedagogical approaches | Teachers have achieved effective results in developing students' spatial understanding through individual approaches. | With individualized approaches, students choose learning methods that suit their needs, helping them to better master the engineering graphics course. |
| Teachers have achieved effective results in developing students' spatial understanding through individual approaches | Teachers have achieved effective results in developing students' spatial understanding through individual approaches | Students apply their spatial understanding in practical applications in areas such as architecture, design and other engineering disciplines, creating images accurately and effectively. |

The practical significance of the study lies in providing a wide range of recommendations. The use of innovative methods and technologies, making the educational process interactive and developing students' practical skills can be useful not only for engineering graphics, but also for other technical and applied disciplines. Teachers can improve the quality of the educational process by applying these innovative approaches to developing students' spatial representation.

The theoretical and practical significance of the study lies in the fact that it contributes to the creation of new teaching methods in the field of engineering graphics. New approaches to creating and analyzing views help strengthen students' creative and analytical skills. This process plays an important role in developing the skills necessary for students' successful work in technical fields.

There are many promising areas for future research, such as in-depth study of modern technologies, testing new methods and their implementation in the educational system, as well as creating conditions for more effective student development through individual approaches in the educational process. The results of the study can contribute to the development of students' technical and creative skills in the future. Thus, the results of the study showed that the development of students' spatial representation when learning the topic "Views" in engineering graphics helps not only to master theoretical knowledge, but also to develop practical skills. These approaches contribute to improving preparation for real work activities, preparing students

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for their future professional life.

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